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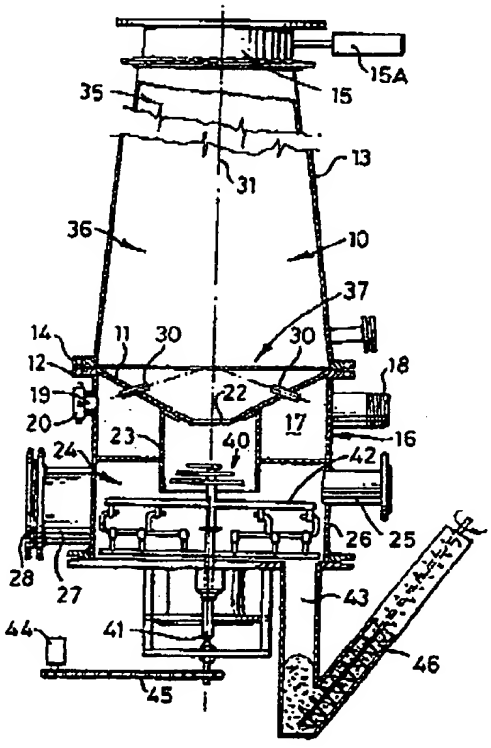
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: GASIFIERS WITH NON RADIAL TUYERES

(57) Abstract

A gasifier for the manufacture of producer gas has a chamber (10) for the combustion of material, the chamber (10) being provided with a plurality of tuyères (30) for the introduction of combustion air to the chamber. The tuyères (30) are disposed at an acute angle to the wall of the chamber (10) so that air is directed both around and upwardly of the chamber. Each tuyères (30) is configured to produce a jet stream wherein the air swirls along the length of the stream.



GASIFIERS WITH NON RADIAL TUYERES

This invention relates to gasifiers and in particular to improvements in or relating to gasifiers whereby improved combustion may take place therewithin. The invention further relates to a method of operating a gasifier.

The production of producer gas (a mixture of about 30% carbon monoxide and 70% nitrogen, though other gases may also be present) is usually performed with a so-called gasifier, in which pyrolysis is performed. The gasifier comprises a chamber provided with air inlets in such a way that the burning of fuel within the chamber take place under controlled conditions. Originally, gasifiers used coal or coke as a fuel source, but interest in gasifiers has recently increased since they may be used for the disposal of various kinds of waste organic solid matter whilst yielding producer gas, which in turn may drive a combined heat and power unit, to yield both heat and electricity. Thus, the solid fuel may typically comprise wood or wood derivatives, straw, poultry litter, dried sewage sludge and refuse-derived combustible material, to mention but a few.

In a gasifier chamber, the solid fuel is reduced to a bed of carbon at a temperature of above 1000°C, a stream of air being passed through the bed with the combustion conditions set so that the oxygen in the air combines with the carbon to form carbon monoxide. Other gases such as methane and hydrogen may also be produced, depending upon the chemical composition of the fuel employed.

A product of the combustion in a gasifier is ash, but this is of relatively low density and of small volume compared to the solid fuel supplied to the gasifier. It is consequently relatively easy to dispose of, especially since it is wholly sterile. By contrast, the producer gas may be used for a variety of purposes, though since it is toxic in view of the carbon monoxide content, it must nevertheless be treated with care. For example, the collected producer gas may immediately be used in an internal combustion engine for the generation of electricity, without being stored for long periods or otherwise handled.

Though the principle upon which a gasifier operates is well known and understood, it is important that the combustion conditions are closely

controlled in order that the production of carbon monoxide is optimised and that the carbon dioxide content of the producer gas is minimised. It has now been established that by controlling the actual introduction of air into the oxidation zone of a gasifier, it is possible to improve the gasifier performance, so increasing the overall efficiency of plant using this equipment.

Gasifier designs have been proposed in NL-A-8900939 and CH-A-237348. In both of these prior designs, arrangements are made to introduce combustion air into a gasifier in such a way that the air is not directed strictly radially with respect to the axis of the combustion chamber, in an attempt to enhance combustion within the chamber. The present invention stems from attempts further to improve the production of producer gas.

According to one aspect of the present invention, there is provided a gasifier for the production of producer gas from combustible material, comprising a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber for the introduction of air into the combustion chamber, each such tuyère defining an axis along which air is projected into the chamber, at least some of the tuyères being configured to impart a rotational motion about said axis along which the air is projected into the chamber from each such tuyère, whereby the combustion air is projected in the form of a jet stream which swirls about the length of the stream.

Preferably, at least some of the tuyères are disposed with their respective axes at an acute angle (when projected on to a horizontal plane containing the respective tuyère) to a tangent to the wall of the chamber at the location of that tuyère, the axis of projection of each said tuyère being in the same sense with respect to the axis of the chamber, whereby the projected air also tends to swirl around the chamber.

It will be appreciated that the gasifier of this invention is able to achieve better reduction of the fuel, by improving the interaction between the introduced air and the hot carbonised bed at the bottom of the gasifier chamber. This interaction may be achieved either solely by causing the

introduced air to rotate along the axis of projection into the gasifier, or by additionally causing the introduced air to swirl around the lower region of the chamber. By adopting both of these measures of this invention, the interaction of the air with the bed at the bottom of the gasifier is much enhanced, so giving better control of the combustion of the fuel. In turn, this leads to more complete combustion in the oxidation zone, giving a greater oxygen deficiency in the reduction zone and raising the proportion of carbon monoxide in the resultant producer gas.

Most preferably, all of the tuyères lie at substantially the same acute angle to the chamber wall where the respective tuyère projects therethrough. Thus, by having the angle of projection of each said tuyère in the same sense with respect to the axis of the chamber, the introduced air tends to swirl around the chamber interacting with all portions of the relatively hot carbon bed. This effect is enhanced by providing the tuyères in a uniform distribution equi-spaced around the chamber.

Advantageously, each tuyère is directed both at a non radial angle to the axis of the chamber and also upwardly of the chamber. In this way, penetration of the entire hot carbon bed by the introduced air may be assured.

The chamber may be of general circular cross-sectional shape, at least in the region of the tuyères, with the axis of the chamber extending generally vertically. That chamber may have a lower wall of a generally conical shape and which supports a bed of the combustible material, said tuyères being mounted in that lower conical wall. At the other end of the chamber, there may be provided an inlet orifice for combustible material, the upper portion of the chamber serving as a hopper for the material loaded thereinto. The inlet orifice advantageously is fitted with a slide valve, to permit charging of the hopper whilst the gasifier is in operation.

Each tuyère is preferably in the form of a nozzle projecting through the chamber wall, the bore of the nozzle being configured to cause the air flow therethrough to rotate about its length. This may be achieved by providing an insert within each said nozzle, the insert comprising a plate the width of

which is substantially the same as the nozzle internal diameter and the plate being twisted along its length.

This invention extends to a method of operating a gasifier for the production of producer gas from combustible material, which gasifier comprises a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber, in which method air is introduced into the combustion chamber through the tuyères and each tuyère is configured to impart a rotational motion about the axis of introduction of the air so that the combustion air is projected in the form of a jet stream which swirls about the length of the introduced stream. In addition, the invention provides for the air being introduced through tuyères at least some of which have their respective axes at an acute angle (when projected onto a horizontal plane containing the respective tuyère) to a tangent to a wall of the chamber at the location of that tuyère, whereby the air will tend to swirl around the chamber, simultaneously with the rotation of the air about its own axis.

By way of example only, one specific embodiment of gasifier constructed and arranged in accordance with the present invention will now be described in detail, reference being made to the accompanying drawings in which:

Figure 1 is a diagrammatic vertical section through the embodiment of the gasifier;

Figure 2 is a plan view on the lower wall of the gasifier chamber shown in Figure 1, with parts removed for clarity;

Figure 3 is a detailed view on an enlarged scale through said lower wall;

Figure 4 is an end-view on a tuyère of the gasifier of Figures 1 to 3; and

Figure 5 illustrates an insert plate of the tuyère nozzle of Figure 4.

Referring initially to Figure 1, there is shown diagrammatically an embodiment of gasifier arranged for the production of producer gas from a solid combustible material serving as a fuel, such as wood chippings, logs, coal or similar materials, poultry litter, dried sewage sludge or a refuse

derived fuel. The gasifier comprises a combustion chamber 10 having a generally conical lower wall 11 provided with a flange 12 around its upper periphery. A hopper 13 has a corresponding flange 14 at its lower periphery and which is secured by bolts (not shown) to flange 12 of the lower wall 11. The upper end of the hopper 13 is closed by a slide valve assembly 15, which permits recharging of the hopper with more solid fuel whilst operation of the gasifier continues. An actuator 15A is mounted to one side of the hopper, to effect opening and closing of the slide valve assembly.

In an alternative arrangement (not shown) the hopper has a simple lid which may be secured in position and a fuel feed arrangement may be provided to supply fuel into the upper part of the hopper.

The lower wall 11 is carried on a base structure 16 which defines a plenum chamber 17 provided with an air inlet 18 and six lighting ports 19, each normally closed by a respective cap 20, the ports 19 being equi-spaced around the plenum chamber 17. The central region of the lower wall 11 communicates through opening 22 with a tube 23 within which the producer gas is formed during operation of the gasifier, the tube 23 leading to a lower chamber 24. A producer gas outlet pipe 25 passes through an outer wall 26 of the lower chamber 24 and there is provided a port 27 to that chamber, normally closed by a blanking plate 28 but through which access to the chamber may be gained for example for ash removal and servicing.

An automated ash removal system is fitted below the tube 23. This comprises an eccentric grate assembly 40 mounted on a shaft 41 rotatably supported below the base wall of the lower chamber 24. The shaft 41 also carries a scraper bar 42 having chains which serve to plough collected ash into a discharge chute 43 below lower chamber 24. A motor 44 is drivingly connected by chain 45 to the shaft 41 to effect rotation of both the grate assembly 40 and the scraper bar 42. A discharge auger 46 takes discharged ash from the chute 43, through a water seal provided at the bottom of that chute.

Air enters the plenum 17 through inlet 18 and passes into the combustion chamber 10 through a plurality of tuyères 30, provided in the conical lower wall 11 of the chamber. As best seen in Figure 2, six such tuyères 30 are provided, equi-spaced around the opening 22 in alignment with the lighting ports 19. The tuyères all lie at substantially the same angle to the vertical axis 31 of the combustion chamber 10 and also all lie at substantially the same angle to a horizontal radius of the chamber intersecting the respective tuyère. Thus, air entering the combustion chamber will tend to swirl around the chamber in a counter-clockwise direction and at the same time to rise upwardly within the chamber.

Each tuyère 30 is fitted with an insert 33 so as to impart a spin on the jet of air issuing from the tuyère into the combustion chamber 10. The insert is in the form of a plate having a width substantially equal to the diameter of the tuyère, as shown in Figure 4, and is twisted through 90° along its length.

In this way, the air passing through the tuyère will be caused to swirl about the axis of the tuyère.

In operation, solid fuel pieces are loaded into the hopper 13 through the slide valve assembly 15 and then the air flow is commenced by reducing the pressure at the producer gas outlet 25. This draws air through inlet 18 into the plenum 17, the air then swirling around that plenum 17 and assisting cooling of the lower plate 11, when operation of the gasifier has been established. From the plenum 17, the air is drawn through the tuyères 30 into the bed on the lower wall 11 and down through opening 22, tube 23 and into the lower chamber 24 by the reduced pressure at the producer gas outlet 25. The gasifier is lit through at least one of the ports 19, for example with a gas torch, and the combustion within the chamber 10 is established. When fully operational, the upper region 35 of the gasifier will be at around 500° C and will serve as a distillation zone for high molecular weight hydrocarbons. Below that, there is a carbonisation zone 36 operating at around 600° C, where the solid fuel is converted to charcoal, by burning off other matter. On and immediately above the lower wall 11, there is established an oxidation zone 37, operating at around 1200° C, where the carbon is burned in air to form CO_2. The hot carbon then falls through opening 22 into tube 23 and on to grate 40, there being a deficiency of oxygen in the tube 23 to continue the combustion of the carbon and so a reduction process takes place, reducing the CO_2 to CO. The final producer gas mixture leaves the lower chamber 24 through pipe 25.

During operation of the gasifier, the motor 47 is operated intermittently slowly to drive the grate assembly 40. The eccentricity of this assembly grinds any large pieces which then fall through the lower chamber 24 and are ploughed into the discharge chute 43. The motor may be operated continuously, depending upon the ash content of the fuel source.

A typical producer gas composition obtained from using wood as a fuel source may be as follows:

GAS	% by weight
Nitrogen	45-54
carbon monoxide	18-25
hydrogen	13-15
water vapour	10-15
carbon dioxide	5-10
methane	3-5

By adopting the measures as described above concerning the disposition of the tuyères and also the internal configuration thereof, and so improving the introduction of air into the oxidation zone through the tuyères, it is found the carbon dioxide content may significantly be reduced, with a consequent improvement in the carbon monoxide content of the producer gas.

CLAIMS

1. A gasifier for the production of producer gas from combustible material, comprising a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber for the introduction of air into the combustion chamber, each such tuyère defining an axis along which air is projected into the chamber, at least some of the tuyères being configured to impart a rotational motion about said axis along which the air is projected into the chamber from each such tuyère, whereby the combustion air is projected in the form of a jet stream which swirls about the length of the stream.

2. A gasifier as claimed in claim 1, wherein at least some of the tuyères are disposed with their respective axes at an acute angle (when projected on to a horizontal plane containing the respective tuyère) to a tangent to the wall of the chamber at the location of that tuyère, the axis of projection of each said tuyère being in the same sense with respect to the axis of the chamber, whereby the projected air also tends to swirl around the chamber.

3. A gasifier as claimed in claim 2, wherein said at least some of the tuyères lie at substantially the same acute angle to the respective tangents to the chamber wall at the location of the respective tuyères.

4. A gasifier as claimed in claim 2 or claim 3, wherein said axis of projection of each tuyère is directed upwardly of the chamber in addition to being directed with its axis at an acute angle to a tangent of the wall when projected on a horizontal plane containing that tuyère.

5. A gasifier as claimed in any of the preceding claims, wherein all of said tuyères are similarly configured and disposed with respect to the chamber.

6. A gasifier as claimed in any of the preceding claims, wherein the chamber is generally of circular cross-sectional shape at least in the region of the tuyères with the axis of the chamber extending generally vertically.

7. A gasifier as claimed in claim 6, wherein the gasifier chamber has a lower wall of generally conical shape which supports a bed of the combustible material, said tuyères being mounted in the lower wall.

8. A gasifier as claimed in any of the preceding claims, wherein said tuyères are distributed substantially uniformly around the chamber.

9. A gasifier as claimed in any of the preceding claims, wherein each said tuyère includes a nozzle which projects through the chamber wall, the bore of the nozzle being configured to cause the air flow therethrough to rotate about said axis of the tuyère.

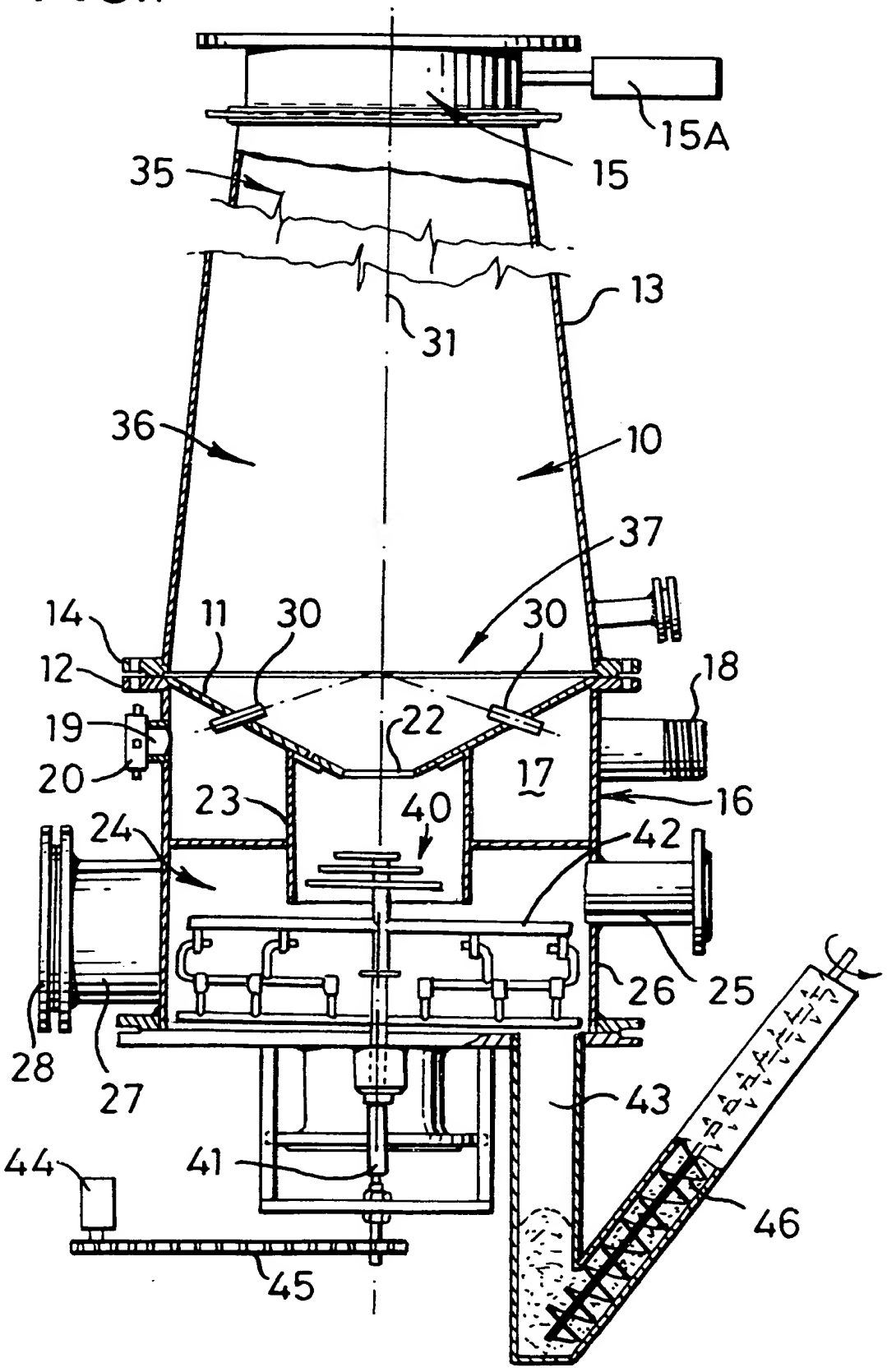
10. A gasifier as claimed in claim 9, wherein an insert is provided within each said nozzle, the insert comprising a plate the width of which is substantially the same as the nozzle diameter and the plate being twisted along its length.

11. A method of operating a gasifier for the production of producer gas from combustible material, which gasifier comprises a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber, in which method air is introduced into the combustion chamber through the tuyères and each tuyère is configured to impart a rotational motion about the axis of introduction of the air so that the combustion air is projected in the form of a jet stream which swirls about the length of the introduced stream.

12. A method as claimed in claim 11, wherein the tuyères are disposed with their respective axes at substantially the same acute angle (when projected onto a horizontal plane containing the respective tuyère) and in the same sense to a tangent to a wall of the chamber at the location of that tuyère whereby air introduced to the chamber through the tuyères tends to swirl around the chamber.

13. A method as claimed in claim 11 or claim 12, wherein the air is drawn through the tuyères by reducing the pressure at the producer gas outlet of the gasifier.

FIG.1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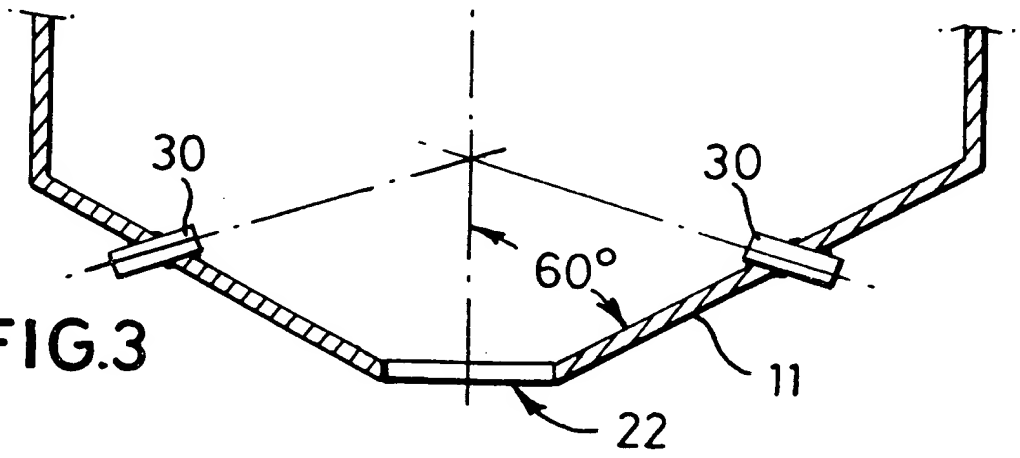
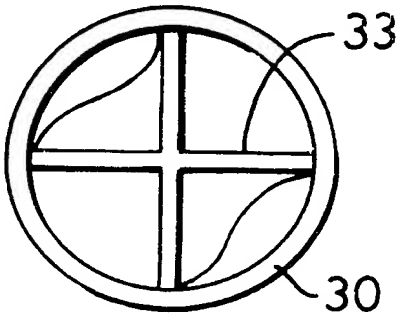


FIG.3

FIG.4



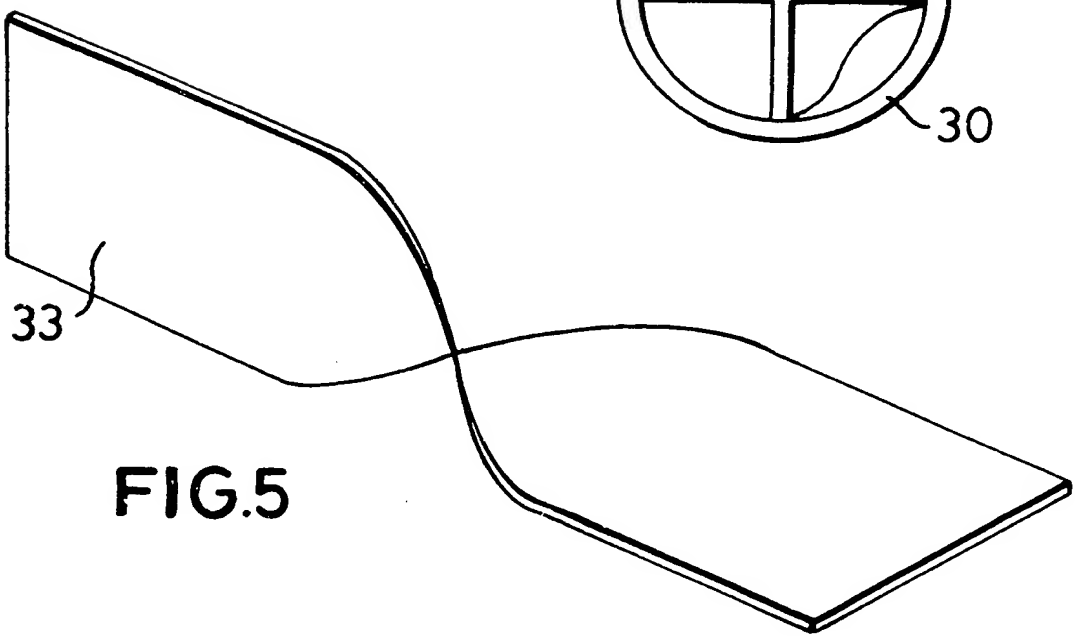


FIG.5

15

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
6/SG/11772		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB99/01671	27/05/1999	28/05/1998
International Patent Classification (IPC) or national classification and IPC C10J3/26		
Applicant DEDAR LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
22/12/1999	15.09.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Goebel, M Telephone No. +49 89 2399 8345

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB99/01671

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1,5-7	as originally filed	
2-4,4a	with telefax of	26/07/2000

Claims, No.:

1-13	with telefax of	26/07/2000

Drawings, sheets:

1/3-3/3	as originally filed

2. The amendments have resulted in the cancellation of:

☐	the description,	pages:	
☒	the claims,	Nos.:	14-15
☐	the drawings,	sheets:	

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

see separate sheet

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1-13
	No:	Claims
Inventive step (IS)	Yes:	Claims 1-13
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1-13
	No:	Claims

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Amendments:

The amendments submitted with your fax dated 26.07.2000 meet the requirements of Art. 34(2)(b) PCT.

The definition of subject-matter in present apparatus claim **1** has been reworded regarding original independent claim 2, from which it is derived, based inter alia on figs. 1-3. Original independent claim 1 is now claim **2**, having been made dependent on claim **1** and clarified based on original claim 12 and fig. 2. Likewise, present independent method claim **11** is derived from reworded original independent method claim 14, now restricted in that **each** tuyere forms a jet stream swirling about the length of the stream and original independent method claim 12 is now claim **12**, having been made dependent on method claim **11** and clarified accordingly.

Amended dependent claims **3**, **4** and **5** are based respectively on original claim 4 and fig. 2, original claim 6 and fig. 2, original claim 5 and page 5, lines 24-27.

The remaining present dependent claims **6-10** and **13** correspond respectively to renumbered original claims 7-11 and 15.

The amendments to the description concern acknowledgement of the prior art **D1** and **D2** (new page 2, lines 7-11), adaptation of the statement of the problem to **D1** and **D2** (new page 2, lines 11-13) and harmonisation with the present claims (new pages 2, line 17 to 3, line 3; new page 4 lines 8-16).

Documents Cited:

Reference is made to the following documents, cited in the international search report:

D1: NL-A-89 00939 (VAN DER VOORT E T J) 1 November 1990
& WPI-Abstract AN 1990-353184 [47]

D2: CH-A-237 348 (F. PORSCHE KG) 1 August 1945

D3: US-A-4 507 174 (KUTRIEB W A) 26 March 1985.

The WPI-Abstract to **D1** was not cited in the search report.

Novelty and Inventive Step:

1. Either of documents **D1** (cf. WPI-Abstract; page 1, lines 9-28; page 3, lines 21-26; **figs. 1, 2**; claims 1, 3, 5) or **D2** (cf. page 1, lines 1-4, 14-22 and 30-41; page 2, lines 6-22; **figs. 1 and 2**; claims 1-3) may be regarded as representing the closest prior

art regarding the subject-matter of present independent apparatus and method claims **1** and **11.** Both documents disclose a (method of operating a) gasifier for production of producer gas from combustible material, comprising (i) a chamber into which said material is introduced, (ii) a plurality of tuyères disposed at or adjacent the lower end of the chamber, through which combustion air is introduced into the combustion chamber, (iii) each such tuyère defining an axis along which air is projected into the chamber.

The subject-matter of present claims **1** and **11** differs from this known (method of operating a) gasifier in that **at least some of the tuyères are configured to impart a rotational motion about said axis, whereby the combustion air is projected in the form of a jet stream which swirls about the length of the stream along said projection axis**.

The subject-matter of present claims **1** and **11** is therefore **novel** (Article 33(2) PCT).

2. The **problem** to be solved by the novel subject-matter of present independent claims **2** and **14** may therefore be regarded as to provide a (method of operating a) gasifier, which shows improved gasifier performance (less CO_2/more CO in producer gas).

3. The solution to this problem proposed in claims **1** and **11** of the present application is considered as involving an **inventive step** (Article 33(3) PCT) for the following reasons:

3.1 Upon reconsideration on behalf of the IPEA, it now appears plausible that the distinguishing feature "swirling jet stream", independent of further features not defined in the claim, provides essentially for the solution of the underlying problem. Thus when an identical radial and axial disposition and of tuyeres vs. **D1** or **D2** is used (e.g. present claims **2** and **12**), the configuration of the presently claimed tuyeres with a therefrom emanating swirling jet stream should indeed provide an improvement, conceivably due to more even heat/oxygen distribution (more turbulence created) and/or a more focussed jet (angular momentum conservation), penetrating the fuel bed deeper.

3.2 This solution is not regarded obvious in view of **D1-D3**, since **D1** and **D2** are **silent**

on any features relating to the presently defined "swirling jet stream" and **D3** (cf. col. 1, lines 42-52; col. 4, lines 27-43; figs. 1-3, 8; claim 1) discloses only twisted inserts (baffles (47)) causing a swirling of the respective gas streams about their length, however in **heat exchanger tubing** (44) for **exhaust gases** (manifolds (32) -> (43)) and within a **different problem** (improve **pyrolysis** reactor, cf. bridging para. cols. 1/2).

4. Claims **2-10** and **12-13** are dependent on claims **1** and **11**, respectively, and as such also meet the requirements of the PCT with respect to novelty and inventive step (Articles 33(2) and (3) PCT).

Certain Defects:

1. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

2. According to the requirements of Rule 11.13(m) PCT the same feature shall be denoted by the same reference sign throughout the application. This requirement is not met in view of the use of **47** for the motor on page 6, line 24 (otherwise denoted as 44)

controlled in order that the production of carbon monoxide is optimised and that the carbon dioxide content of the producer gas is minimised. It has now been established that by controlling the actual introduction of air into the oxidation zone of a gasifier, it is possible to improve the gasifier performance, so increasing the overall efficiency of plant using this equipment.

According to one aspect of the present invention, there is provided a gasifier for the production of producer gas from combustible material, comprising a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber and through which combustion air is introduced into the combustion chamber, at least some of the tuyères being disposed at an acute angle to the wall of the chamber in which the tuyères are mounted, whereby the air is directed into the chamber away from the centre thereof.

According to a second aspect of the present invention, there is provided a gasifier for the production of producer gas from combustible material, comprising a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber and through which air is introduced into the combustion chamber, at least some of the tuyères being arranged to introduce the air in the form of a jet stream wherein the air in the stream swirls about the length of the stream.

It will be appreciated that the gasifier of this invention is able to achieve better reduction of the fuel, by improving the interaction between the introduced air and the hot carbonised bed at the bottom of the gasifier chamber. This interaction may be achieved in either of two ways, or preferably by a combination of both of these ways. Thus, the introduced air may be caused to swirl around the lower region of the chamber, or may be in the form of a jet which is caused to swirl along its length as it is introduced into the chamber. By adopting both of these measures of this invention, the interaction of the air with the bed at the bottom of the gasifier is much enhanced, so giving better control of the combustion of the fuel. In turn, this leads to more complete combustion in the oxidation zone, giving a greater

oxygen deficiency in the reduction zone and raising the proportion of carbon monoxide in the resultant producer gas.

Most preferably, all of the tuyères lie at substantially the same acute angle to the chamber wall where the respective tuyère projects therethrough. Thus, by having the angle of projection of each said tuyère in the same sense with respect to the axis of the chamber, the introduced air tends to swirl around the chamber interacting with all portions of the relatively hot carbon bed. This effect is enhanced by providing the tuyères in a uniform distribution equi-spaced around the chamber.

Advantageously, each tuyère is directed both at a non radial angle to the axis of the chamber and also upwardly of the chamber. In this way, penetration of the entire hot carbon bed by the introduced air may be assured.

The chamber may be of general circular cross-sectional shape, at least in the region of the tuyères, with the axis of the chamber extending generally vertically. That chamber may have a lower wall of a generally conical shape and which supports a bed of the combustible material, said tuyères being mounted in that lower conical wall. At the other end of the chamber, there may be provided an inlet orifice for combustible material, the upper portion of the chamber serving as a hopper for the material loaded thereinto. The inlet orifice advantageously is fitted with a slide valve, to permit charging of the hopper whilst the gasifier is in operation.

Each tuyère is preferably in the form of a nozzle projecting through the chamber wall, the bore of the nozzle being configured to cause the air flow therethrough to rotate about its length. This may be achieved by providing an insert within each said nozzle, the insert comprising a plate the width of which is substantially the same as the nozzle internal diameter and the plate being twisted along its length.

This invention extends to a method of operating a gasifier for the production of producer gas from combustible material, which gasifier comprises a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber, in which method air is introduced into the combustion chamber through the tuyères in

such a way that the air swirls around the lower region of the gasifier chamber as the air rises up through a hot carbonised bed of the combustible material. Alternatively, or in addition, the method provides for the air being introduced through at least some of those tuyères being in the form of a jet-stream wherein the air in the stream swirls around the length of the stream.

By way of example only, one specific embodiment of gasifier constructed and arranged in accordance with the present invention will now be described in detail, reference being made to the accompanying drawings in which:

Figure 1 is a diagrammatic vertical section through the embodiment of the gasifier;

Figure 2 is a plan view on the lower wall of the gasifier chamber shown in Figure 1, with parts removed for clarity;

Figure 3 is a detailed view on an enlarged scale through said lower wall;

Figure 4 is an end-view on a tuyère of the gasifier of Figures 1 to 3; and

Figure 5 illustrates an insert plate of the tuyère nozzle of Figure 4.

Referring initially to Figure 1, there is shown diagrammatically an embodiment of gasifier arranged for the production of producer gas from a solid combustible material serving as a fuel, such as wood chippings, logs, coal or similar materials, poultry litter, dried sewage sludge or a refuse derived fuel. The gasifier comprises a combustion chamber 10 having a generally conical lower wall 11 provided with a flange 12 around its upper periphery. A hopper 13 has a corresponding flange 14 at its lower periphery and which is secured by bolts (not shown) to flange 12 of the lower wall 11. The upper end of the hopper 13 is closed by a slide valve assembly 15, which permits recharging of the hopper with more solid fuel whilst operation of the gasifier continues. An actuator 15A is mounted to one side of the hopper, to effect opening and closing of the slide valve assembly.

In an alternative arrangement (not shown) the hopper has a simple lid which may be secured in position and a fuel feed arrangement may be provided to supply fuel into the upper part of the hopper.

CLAIMS

1. A gasifier for the production of producer gas from combustible material, comprising a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber and through which combustion air is introduced into the combustion chamber, at least some of the tuyères being disposed at an acute angle to the wall of the chamber in which the tuyères are mounted, whereby the air is directed into the chamber away from the centre thereof.

2. A gasifier for the production of producer gas from combustible material, comprising a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber and through which air is introduced into the combustion chamber, at least some of the tuyères being arranged to introduce the air in the form of a jet stream wherein the air in the stream swirls about the length of the stream.

3. A gasifier as claimed in claim 2, wherein said at least some of the tuyères being are disposed at an acute angle to the wall of the chamber in which the tuyères are mounted, whereby the air is directed into the chamber away from the centre thereof.

4. A gasifier as claimed in claim 1 or claim 3, wherein said at least some of the tuyères all lie at substantially the same acute angle to the chamber wall where the respective tuyère projects therethrough.

5. A gasifier as claimed in claim 4, wherein the angle of projection of each said tuyère is in the same sense with respect to the axis of the chamber, whereby the introduced air tends to swirl around the chamber.

6. A gasifier as claimed in claim 4 or claim 5, wherein each tuyère is directed both at a non-radial angle to the axis of the chamber and also upwardly of the chamber.

7. A gasifier as claimed in any of the preceding claims, wherein the chamber is generally of circular cross-sectional shape at least in the region of the tuyères with the axis of the chamber extending generally vertically.

8. A gasifier as claimed in claim 7, wherein the gasifier chamber has a lower wall of generally conical shape which supports a bed of the combustible material, said tuyères being mounted in the lower wall.

9. A gasifier as claimed in any of the preceding claims, wherein said tuyères are distributed substantially uniformly around the chamber.

10. A gasifier as claimed in claim 2 or any claim depending thereon, wherein each said tuyère is in the form of a nozzle projecting through the chamber wall, the bore of the nozzle being configured to cause the air flow therethrough to rotate about its length.

11. A gasifier as claimed in claim 10, wherein an insert is provided within each said nozzle, the insert comprising a plate the width of which is substantially the same as the nozzle diameter and the plate being twisted along its length.

12. A method of operating a gasifier for the production of producer gas from combustible material, which gasifier comprises a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber, in which method air is introduced into the combustion chamber through the tuyères so that the air swirls around the lower region of the gasifier chamber as the air rises up through a hot carbonised bed of the combustible material.

13. A method as claimed in claim 12, wherein the air introduced through at least some of the tuyères being is the form of a jet stream wherein the air in the stream swirls about the length of the stream.

14. A method of operating a gasifier for the production of producer gas from combustible material, which gasifier comprises a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber, in which method air is introduced into the combustion chamber through the tuyères, the air being introduced through at least some of the tuyères being in the form of a jet stream wherein the air in the stream swirls about the length of the stream.

15. A method as claimed in any of claims 12 to 14, wherein the air is drawn through the tuyères by reducing the pressure at the producer gas outlet of the gasifier.

M.H

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 14 February 2000 (14.02.00)	
International application No. PCT/GB99/01671	**Applicant's or agent's file reference** 6/SG/11772
International filing date (day/month/year) 27 May 1999 (27.05.99)	**Priority date** (day/month/year) 28 May 1998 (28.05.98)
Applicant LING, Michael, John, Archer	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

22 December 1999 (22.12.99)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Juan Cruz
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
6/SG/11772		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 99/01671	27/05/1999	28/05/1998
Applicant		
DEDAR LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   GASIFIERS WITH NON RADIAL TUYERES

5. With regard to the **abstract**,

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/01671

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C10J3/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C10J C10B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NL 8 900 939 A (EDUARD THOMAS JACOBUS VAN DER) 1 November 1990 (1990-11-01) page 1, line 9 - line 14; claims; figures page 3, line 21 - line 26	1,4-9, 12,14
A	CH 237 348 A (F. PORSCHE) 1 August 1945 (1945-08-01) page 1, line 14 - line 22; claims; figures	1,4-9, 12,14
A	US 4 507 174 A (KUTRIEB WOLFGANG A) 26 March 1985 (1985-03-26) column 4, line 26 - line 43; claims; figure 8	2,10,11, 13

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 September 1999	06/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Lapeyrere, J

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/01671

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
NL 8900939 A	01-11-1990	NONE	
CH 237348 A		NONE	
US 4507174 A	26-03-1985	NONE	